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Discovering Long-lived Particles at DUNE

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Long-lived particles (LLPs) arise in many theories beyond the Standard Model. These may be copiously produced from meson decays (or through their mixing with the LLP) at neutrino facilities and leave a visible decay signal in nearby neutrino detectors. We compute the expected sensitivity of the DUNE liquid argon (LAr) and gaseous argon (GAr) near detectors (ND) to light LLP decays. In doing so, we determine the expected backgrounds for both detectors, which have been largely overlooked in the literature, taking into account their angular and energy resolution. We show that searches for LLP decays into muon pairs, or into three pions, would be extremely clean. Conversely, decays into two photons would be affected by large backgrounds from neutrino interactions for both near detectors; finally, the reduced signal efficiency for e+e− pairs leads to a reduced sensitivity for ND-LAr. Our results are first presented in a model-independent way, as a function of the mass of the new state and its lifetime. We also provide detailed calculations for several phenomenological models with axion-like particles (coupled to gluons, to electroweak bosons, or to quark currents). Some of our results may also be of interest for other neutrino facilities using a similar detector technology (e.g. MicroBooNE, SBND, ICARUS, or the T2K Near Detector).

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